(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: **0 151 558**
A1

(12) # EUROPEAN PATENT APPLICATION

(21) Application number: 85850010.1

(22) Date of filing: 08.01.85

(51) Int. Cl.⁴: F 01 N 1/02

(30) Priority: 10.01.84 SE 8400084

(43) Date of publication of application:
14.08.85 Bulletin 85/33

(84) Designated Contracting States:
AT BE CH DE FR GB IT LI LU NL SE

(71) Applicant: UNIKAT AB
Postbox 6141
S-200 11 Malmö(SE)

(72) Inventor: Hergart, Anders
Karbogatan 35
S-212 33 Malmö(SE)

(74) Representative: Ström, Tore et al,
Ström & Gullikson AB Studentgatan 1 P.O. Box 4188
S-203 13 Malmö(SE)

(54) **Particle filter for cleaning exhaust gas from internal combustion engines.**

(57) Particle filter for cleaning exhaust gas from internal combustion engines, comprising a filter element (10) with inlet and outlet passages (11) extending in parallel and separated by porous walls. The passages are arranged substantially vertically with the inlet passages opening downwards, and an electric heater (20,21) is arranged below the filter element.

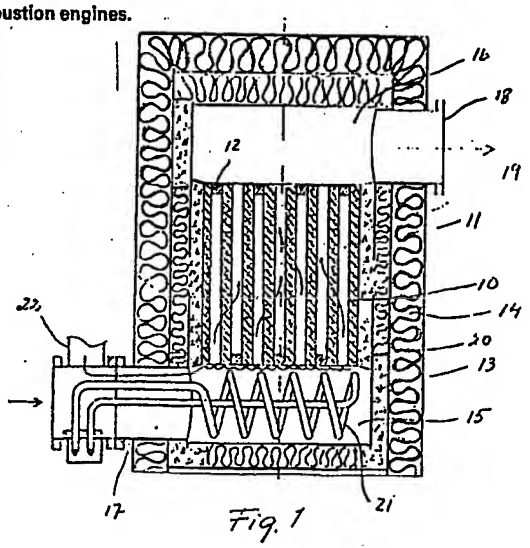

Fig. 1

EP 0 151 558 A1

PARTICLE FILTER FOR CLEANING EXHAUST GAS FROM INTERNAL COMBUSTION ENGINES

The present invention relates to a particle filter for cleaning exhaust gas from internal combustion engines.

The particle content of the exhaust gas from internal combustion engines, primarily Diesel engines, usually comprises coal particles (soot) originating from imperfect combustion of hydrocarbon fuels at specific operating conditions of the engine. For environmental considerations these particles should be separated from the exhaust gas before the exhaust gas is allowed to escape to the atmosphere. At the separation of the particles in the filter, the particles are deposited on the primary side of the filter and form a coating which increases the pressure drop over the filter if it is not removed. However, the coating will disappear if the exhaust gas passing through the filter is at sufficient temperature so as to burn off the coating, i.e. at a temperature of at least 650 to 700^{o}C, and the oxygen content of the exhaust gas passing through ranges from 8 to 10 % by volume.

The temperature of the exhaust gas from an internal combustion engine is dependent on the rpm and the load of the engine. At cold start, the exhaust gas is practically at the temperature of the surroundings. At idling, the temperature of the exhaust gas ranges from 100 to 180^{o}C, depending on the size of the engine, and at load, the temperature may rise to 200 to 650^{o}C. However, only at a high load and a high rpm of the engine, there is reached such temperature of the exhaust gas that the conditions allow the particle coating in the filter to be burnt off, i.e. that the filter will be regenerated without specific measures.

However, the operating conditions of many internal combustion engines in vehicles, working machines, and stationary plants are such that the exhaust gas temperature necessary for regeneration of the filter will not be reached at least not sufficiently often for the pressure drop over the filter being kept within acceptable limits. This is true particularly for intermittently operating Diesel engines.

In such cases wherein the exhaust gas from the internal combustion engine is not at sufficient temperature so as to regenerate the filter due to the operating conditions of the engine, it has been proposed to increase the temperature of the exhaust gas by supplying energy from outside. Thus, the Swedish patent application 8008527-7 describes a device for regenerating an exhaust gas filter wherein a liquid or gaseous fuel is burnt intermittently catalytically in the exhaust gas flow from the internal combustion engine. Such a device requires an extensive control system in order to operate satisfactorily and to meet the specific safety requirements which may apply to the vehicle, machine, or plant in full wherein the internal combustion engine is used. To obtain the temperature rise by such combustion in the exhaust gas system may be a conceivable alternative to operation of the internal combustion engine temporarily at a high rpm in order to increase the exhaust gas temperature, but for practical or economical reasons such supplementary equipment in many cases may be considered an unrealistic solution of the problem.

The purpose of the invention is to provide regeneration of a particle filter in a constructively and functionally simple manner for cleaning the exhaust gas from internal combustion engines by the supply of energy from the outside while obtaining great safety and without using extensive control equipment. The particle filter

of the invention comprises in a known manner a filter element with inlet and outlet passages extending in parallel and separated by porous walls. According to the invention, a particle filter of this kind has obtained, for the purpose mentioned, the characteristics appearing from the claim.

This particle filter can be regenerated by the exhaust gas passing through in the usual manner when the exhaust gas is at sufficient temperature to burn an existing coating in the filter. However, when the temperature of the exhaust gas is not sufficient, the regeneration is effected by electric heating of the filter, which can take place at no other gas flow than that obtained by "chimney effect" in the passages of the filter element. This provides two advantages, viz. low energy consumption and low risk of overheating of the filter with accompanying risk of heat shock or strain.

In order to explain the invention in more detail an embodiment thereof will be described with reference to the accompanying drawings in which

FIG. 1 is an axial sectional view of a particle filter according to the invention,

FIG. 2 is a cross-sectional view of the particle filter, and

FIG. 3 is a side view of the particle filter as seen from the inlet or primary side thereof.

The particle filter shown in the drawings comprises a monolithic porous filter element 10 of ceramic material. This filter element can be of the brand CELLOR from Corning, USA, and comprises a number of passages 11 extending in parallel and having square cross-sectional form, which extend between opposite surfaces of the filter element but are plugged at 12 alternatingly at one end and the other. The filter element is disposed

with the passages 11 substantially vertical and is embedded into refractory cement 13 or a similar material which is surrounded by a heat-insulating layer 14. Below the filter element there is provided a compartment 15 which is an inlet compartment, and above the filter element there is provided a compartment 16 which is an outlet compartment. The inlet compartment is provided with an inlet socket 17 of metal sheet while the outlet compartment has an outlet socket 18 also of metal sheet, and the filter element 10 with the embedment 13 and the insulation 14 is enclosed into a metal sheet casing 19 to which the sockets 17 and 18 preferably are secured. Thus, there is no metallic connection between the filter element proper and the casing 19.

In the inlet compartment 15 which is the primary side of the filter, a heater is provided, and in the drawings, two different alternative embodiments of this heater are shown. The heater can comprise a glow wire 20 mounted close to the lower side of the filter element 10, or a helical heater 21 of the type consisting of a metal tube which is filled e.g. with magnesia and receives a glow wire embedded therein. The heater is constructed for connection to the electric mains or other external power source for heating the filter element 10.

The particle filter described should be connected at the inlet socket 17 to the exhaust gas system of an internal combustion engine e.g. a Diesel engine, for the supply of exhaust gas with particles entrained therein, through the inlet socket 17 to the inlet compartment 15. When the engine is operating, the heater 20 or 21, respectively, is disconnected and the exhaust gas passes into the passages 11 of the filter element 10, which are open at the bottom, to pass through the porous partition walls between the passages into the passages 11 which are

open at the top. When the exhaust gas passes through the porous walls, solid particles present in the exhaust gas, are deposited onto the surface of the porous walls at the primary side of the filter element 11, i.e. in the passages open at the bottom, so that cleaned exhaust gas will enter the outlet compartment 16 to escape to the atmosphere through the outlet socket 18. The solid particles caught at the primary side of the filter element 10 will be burnt if the exhaust gas is at a sufficiently high temperature, i.e. a temperature of at least 650 to 700^{0}C, and also provided that there is a sufficient rest of oxygen in the exhaust gas to make possible that the particles are burnt. As mentioned above, the exhaust gas will not under specific operating conditions of the internal combustion engine reach the required ignition temperature. In that case, there will be no continuous regeneration of the filter; eventually, a coating of solid particles and primarily soot particles will build up at the primary side of the filter element 10.

By means of the heater 20 or 21 the filter 10 in that case is heated by means of energy supplied from the outside in order to burn off the coating. An additional air inlet 22 is provided on the inlet socket 17 for the supply of air from the outside such that there is obtained in the filter an oxygen content of 8 to 10 % by volume. The inlet 22 can be controlled e.g. by means of a solenoid valve. Due to the fact that the heater is mounted below the filter element there is obtained a natural and advantageous heat distribution through the filter at the regeneration effected by electric heating of the filter element, the heating of the filter element being effected rapidly and uniformly, because no heat is lead off from the filter element by the manner in which said element is mounted, no cold regions being formed in

the filter element or the immediate surroundings thereof.

The filter element 10 must be dimensioned with due consideration of the exhaust gas flow rate and also the regeneration intervals which can be applied in practice, and in this connection the heat effect of the heater has to be adapted to the size of the filter. The heater should be provided with an overheating protection device the operation of which is based on leakage current measurement.

Thus, it will be seen that the particle filter described can be regenerated during operation when the exhaust gas passing through is at a sufficiently high temperature, as well as during stoppage by electric heating of the filter element.

When the particle filter is used in a vehicle, the heater can be supplied from an electric power source in the vehicle. This power source can comprise e.g. a generator driven by the vehicle at braking.

A particle filter of the embodiment described can replace the conventional muffler and/or a spark arrester.

The primary side of the filter can be plated with a catalyst (not noble metal) for lowering the ignition temperature of collected coal particles forming the major constituent of the coating on the primary side of the filter element, to a temperature of about 400°C. Also on the secondary side, the filter element can be plated with a catalyst, but in this case a noble metal catalyst for afterburning of carbon monoxide, hydrocarbons, and other combustible gaseous compositions in the exhaust gas such that these substances are prevented from escaping into the surroundings, which should be prevented in view of environmental considerations. However, it is presumed that a sufficient temperature is maintained in the filter element and that the oxygen content of the exhaust gas is

sufficient for burning carbon monoxide, hydrocarbons, and other combustible compositions. This requirement can very well be met with the particle filter of the invention, which thus can replace other devices for catalytic exhaust gas cleaning.

The periods when the filter element 10 is being heated electrically should not be limited to short temperature peaks; the filter element should be maintained at the elevated temperature for an extended period. Since there is no gas flow through the filter element during the regeneration, the energy consumption will be considerably lower than in the case of burning a gaseous or liquid fuel in the filter for increasing the temperature of the filter element.

The embodiment of the particle filter of the invention described herein can be modified as to the construction thereof within the scope of the invention.

CLAIM

Particle filter for cleaning exhaust gas from internal combustion engines, comprising a filter element (10) having passages (11) extending substantially vertically in parallel, some of which are connected as inlet passages to an inlet compartment (15) located at the bottom, and others of which are connected as outlet passages to an outlet compartment (16) located at the top, the inlet and outlet passages being separated by porous walls, and an electric heater (20, 21) arranged in the inlet compartment below the filter element for regenerating the filter, c h a r a c t e r i z e d in that the filter element (10), for regeneration of the filter during stoppage of the engine, is enclosed by a heat-resistant and heat-insulating material (13, 14) and has at the inlet side a catalyst for lowering the combustion temperature of separated soot particles, and at the outlet side a catalyst for catalytic combustion of gaseous components of the exhaust gas, an air inlet (22) also being provided at the inlet side of the filter element (10).

0151558

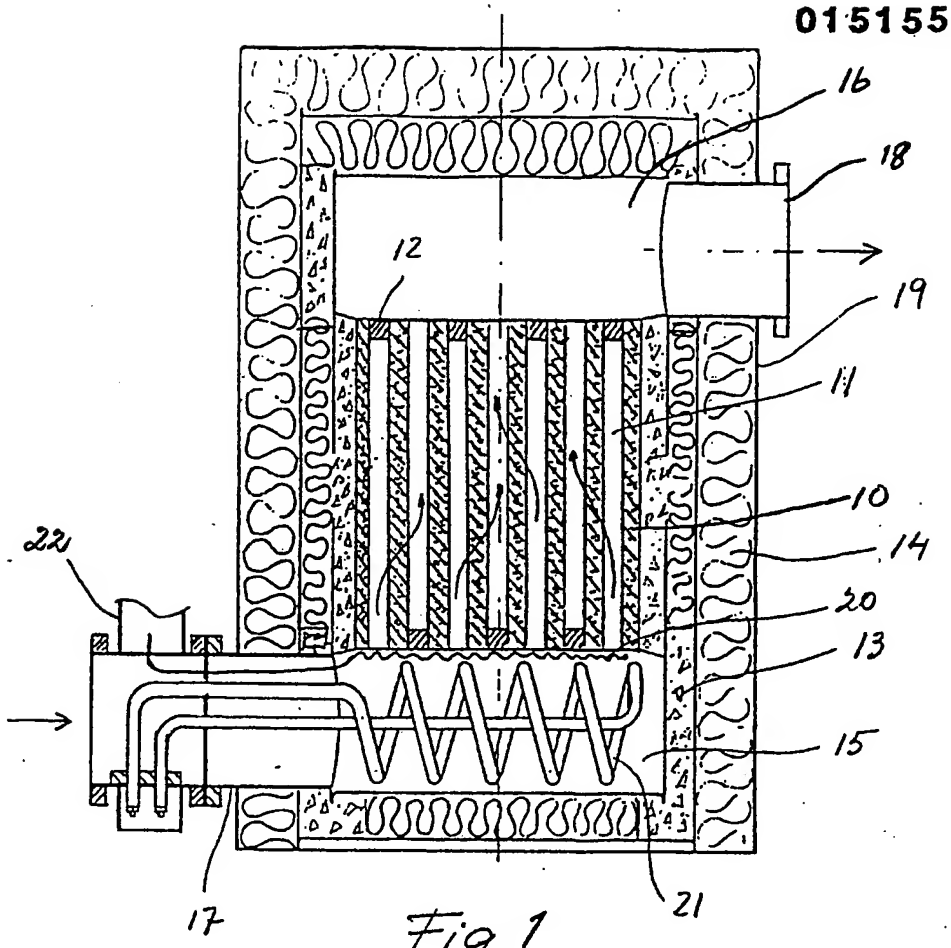

Fig. 1

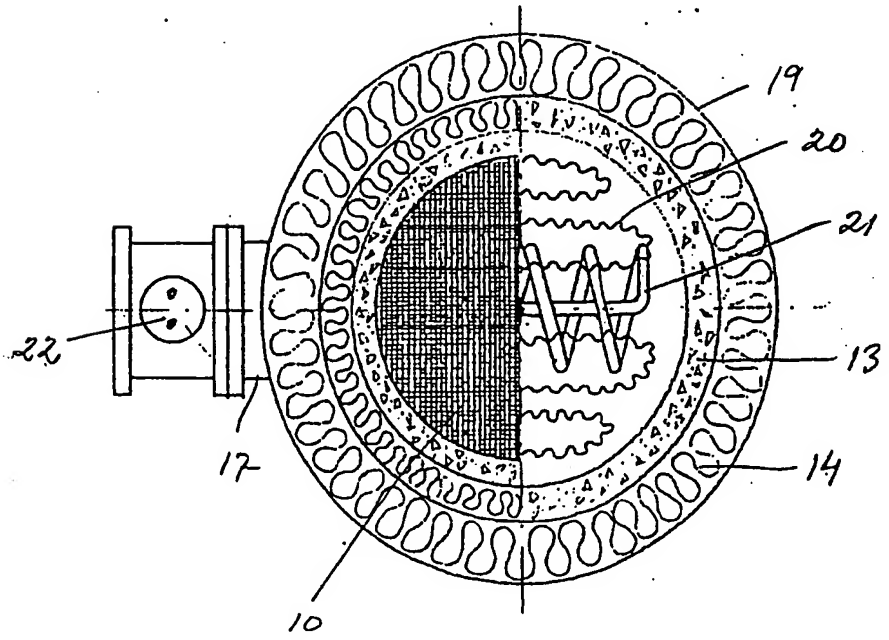

Fig. 2

0151558

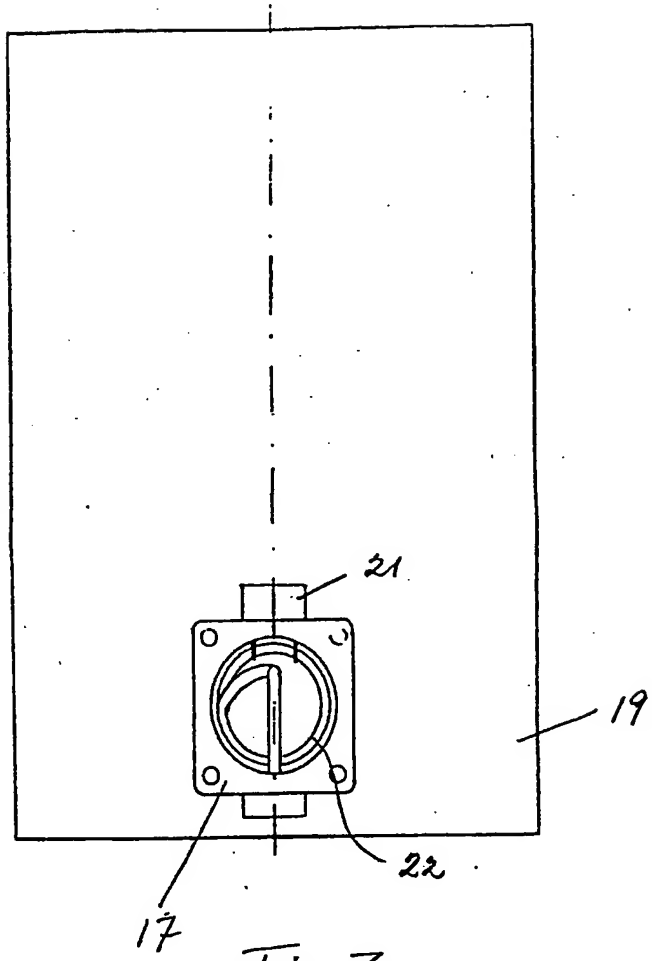

Fig. 3

0151558

European Patent Office

EUROPEAN SEARCH REPORT

Application number

EP 85 85 0010

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.4)
X	US-A-4 404 795 (OISHI) * Column 3, line 38 - column 4, line 57; figures 1,2 *	1	F 01 N 1/02
A	US-A-4 359 864 (BAILEY) * Column 4, lines 24-64; figure 4 *	1	
A	GB-A-2 064 983 (TEXACO) * Page 2, lines 18-61; figure 2 *& SE - A - 8 008 527 (Cat. D)	1	
A	DE-A-2 951 316 (DEGUSSA) * Page 11, lines 1-30; page 12, line 23 - page 14, line 8; figures 1,4 *	1	
A	EP-A-0 020 766 (SHIMIZU) * Page 11, line 13 - page 14, line 4; figure 2 *	1	TECHNICAL FIELDS SEARCHED (Int. Cl.4) F 01 N
A	GB-A-2 114 913 (TEXACO) * Page 2, line 35 - page 5, line 37; figures 2-6 *	1	

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	17-04-1985	HAKHVERDI M.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO Form 1503. 03.82